

**Advanced Creative Enquiry
M6X01787**

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A note to reader. In early December a drive containing the original research portfolio corrupted. While I managed to recover the vast majority of work, it is no longer in exact order of when the research was done. I have reconfigured it to the best of my knowlege.

I have configured and grouped work that may be weeks apart.

Problem Statement

Current cooling solutions for home desktop computers have remained the same over the past few decades. Consumer desktop cooling has been done in one or two ways, most commonly by fans. While this has been effective in the past, as processing cores have become smaller, the number of cores has increased to create more powerful machines. In turn, heat generated by the desktop computer has increased. Alternatively, liquid cooling is used; this is uncommon and often needs to be maintained by the customer.

Adding more fans and increasing airflow through the case causes faster dust accumulation, noise, and energy consumption. In this project, I would like to explore alternative solutions to this problem. I am creating a desktop with superior cooling at a lower energy cost and lower maintenance.

A I R

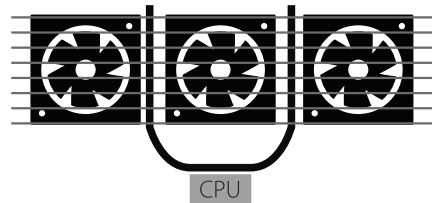


Fan: ST120 (Lian Li, 2022)

How it works.

Fan cooling utilises a heat pipe that moves the heat to metal fins. A fan moves air through these fins to dissipate heat quickly.

The size of the heatsink and amount of fans needed varies greatly.



Whats good.

- This technology is affordable. *
- Quick to manufacture.
- Easy to maintain.

Whats bad.

- Bulky
- Loudest Consumer Technology
- Poor Aesthetics
- Hard to Clean
- *When mass produced

Aesthetics:

Metals, whites, blacks.



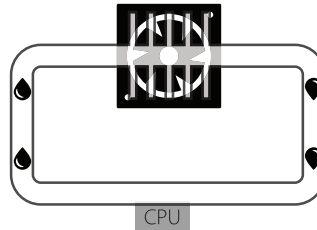
IMAGE OF RADIATOR: NH-D15S (Noctua, 2022)

LIQUID

How it works.

Liquid cooling doesn't use heat pipes. Instead a water pump is used to move water from the processor unit to a heat sink.

Fans push air through the heatsink. While fewer fans are often needed, this process often still requires fans.



Whats good.

- Very effective cooling
- Quiet
- Waterloops can be Aesthetic

Whats Bad.

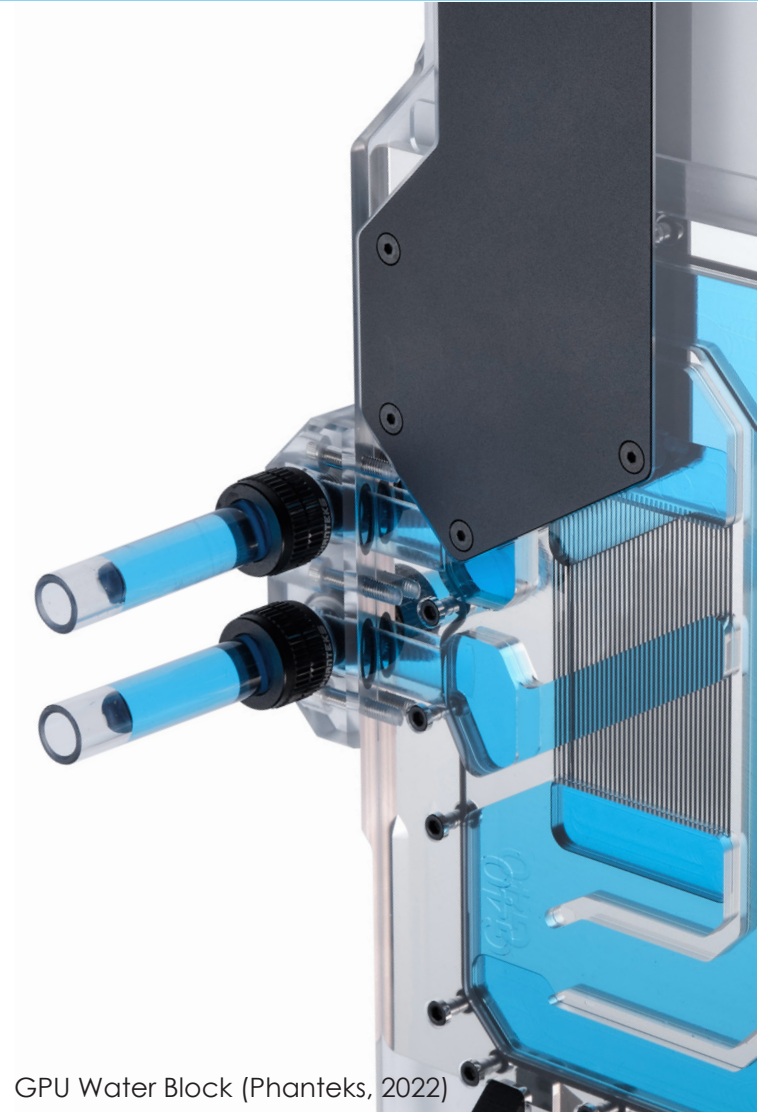
- Difficult to Maintain
- Leak Risk
- Higher Cost - Machining CNC mill required for water 'fins'.

Aesthetics:

Clear, Metals, Blacks, Coloured Liquid



Pump & reservoir (EKWB, 2022)



GPU Water Block (Phanteks, 2022)

Heatpipe (Cofan, 2022)

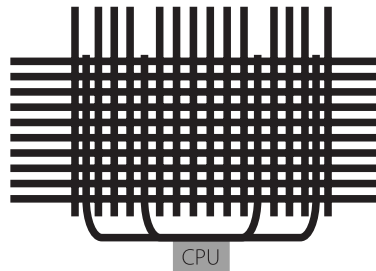


FANLESS

How It works.

No moving parts utilises heat pipes.

Often a large array of heatpipes are used to disperse heat to a large area, others use heatpipes and heat sinks.



Whats good.

- Very Efficient - no electrics needed
- Completely Silent

Whats Bad.

- Not Aesthetic
- Highest Cost
- Very difficult to Manufacture -
- Hard to weld heat pipes
- Large footprint for Powerful machines

Aesthetics:

Black, Metal, Anodized aluminium

Fanless Desktop (Akasa, 2022)



USER PREFERENCE DESKTOP SURVEY

Do the users like
a window to see
hardware?

Yes - 93.3%

What does the
user find most
important?

- 1) Cooling
- 2) Quiet
- 3) Aesthetics
- 4) Compact

Desktop Case
Colour

Gray Scale - 33%
All Black - 20%
Solid Colour Dark -
13.3%
All White - 13.3%
Solid Colour Pastel -
13.3%
Natural Metal (Not
Painted) - 6.7%

How often do you
change or upgrade
components

Rarely - 40%
Never - 40%
Occasionally -
13.3%
Very Often - 6.7%

Do you like lighting
in your PC?

Yes - 100%

How often do you
clean your PC from
dust?

Occasionally - 53.3%
Never - 20%
Often - 13.3%
Rarely - 13.3%



Specs:

- Case Cost €790
- Heatsink Technology
- Optional twin 140mm fans (not so fanless)
- Cooling capability 400W TDP
- (HxLxW), 450 mm x 380 mm x 210 mm
- Difficult to upgrade.

THE BEAST

MARKET RESEARCH



'The Beast' (Monsterlabo, 2022)

Monsterlabos 'The Beast' is a very large desktop, simply fitted with two massive heatsinks, one for the GPU and one for the CPU. It claims a 400W TDP, which we will assume is combined so a 200W each. While the GPU should have a higher TDP due to power consumption I will assume its a 150W CPU heatsink and 250W GPU heatsink. The design is minimal but features a clear section allowing the user to see their hardware, or what is not cut off by the heatsinks.

Specs:

- Cost Prebuilt from €1666 (case cost > €1000)
- Heat Rod Technology
- 160W TDP Per Panel – 2 Panels 320W TDP
- (HxLxW), 300mm x 255mm x 100mm
- Very difficult to upgrade

AIRTOP3

MARKET RESEARCH

The Airtop is a good mid-range desktop. Its styling appears to be bauhaus inspired, and this succeeds in giving it a rugged look. Due to its custom contacts to the GPU and CPU, it would make replacing the internals very difficult and not possible for the average consumer.



Airtop3 photos (FIT-IOT, 2022)



Project Aims

From looking at survey results, current competition and cooling methods, the aims for this project currently are:

01

Cooling.

All current consumer desktops that use fanless cooling can only cool midrange components.

02

Upgradable.

No current fanless case has complete upgrade options. This is due to their inhouse manufactured heatsink contacts.
60% of the 16 survey participants upgrade their PC.

03

Low Maintenance.

80% of users clean their desktop regularly from dust. The Desktop should create a quick and easy way to clean or maintenance free.

04

Lights and Windows.

Users like being able to see their hardware, none of the competitors allow for high visibility.

Due to these objectives, I believe the best way to achieve all is through a liquid cooling solution. The reasons for this are:

- Best cooling solution on the market
- Companies are always coming out with new waterblocks - making upgrades easy for any component.
- Maintenance is higher, but potential for fewer internal needs to clean as water can be pumped anywhere.
- There is less obstruction of components and more free space compared to heatsinks.

Concept 01

Liquid Cooled.

Using a similar concept to 'The Beast' but using a large liquid radiator to dissipate heat. This can be built into the sides of the case.

PC water cooling radiators exist, but they are designed for the top and front thin panels of desktop cases. By designing one for the side we could create a greater surface area allowing the water to cool closer to ambient temperatures using less equipment.

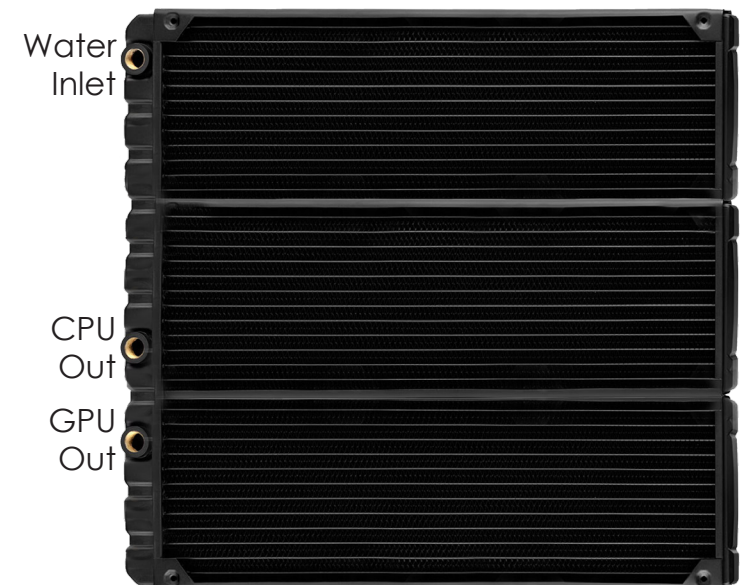
Requirements: Water blocks, Pipes, Fittings, Water reservoir and Pump



360mm Water Radiator (XSPC, 2022)



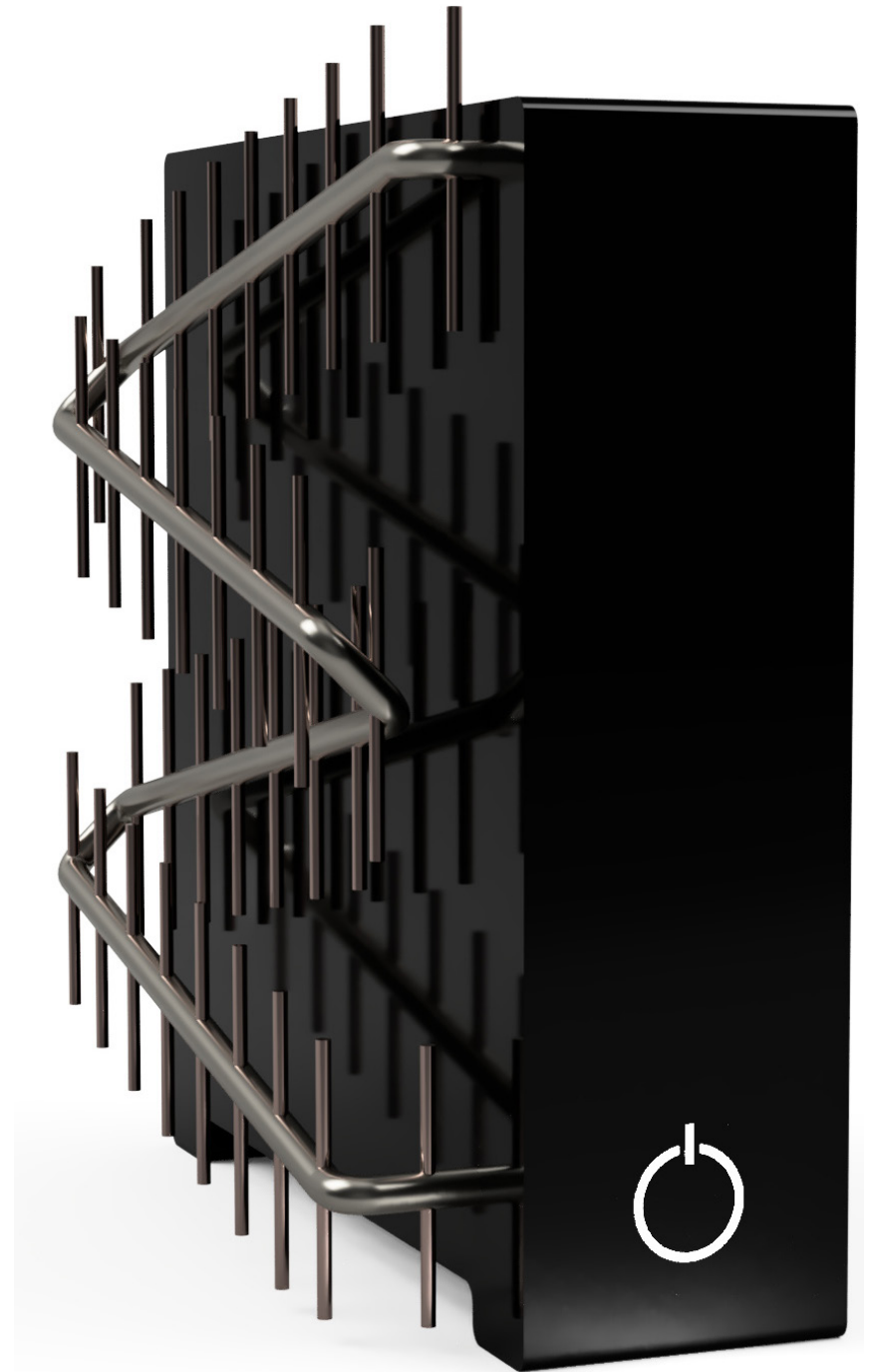
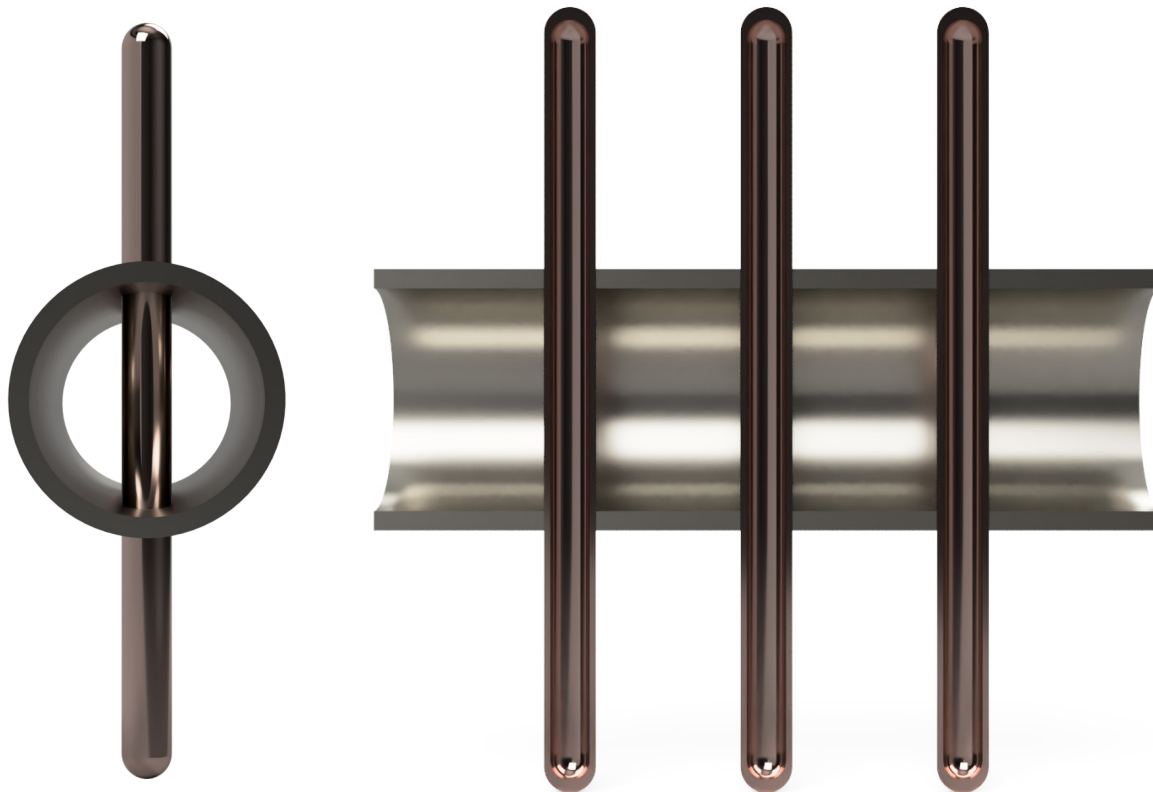
Initial concept render



Concept 02

Tube heatpipe hybrid.

Heatpipes are currently the fastest way to transport heat. In this concept I have encoperated heatpipes through the main water transfer pipe. They each act like miniture heatsinks as the water flows from and to the processors.

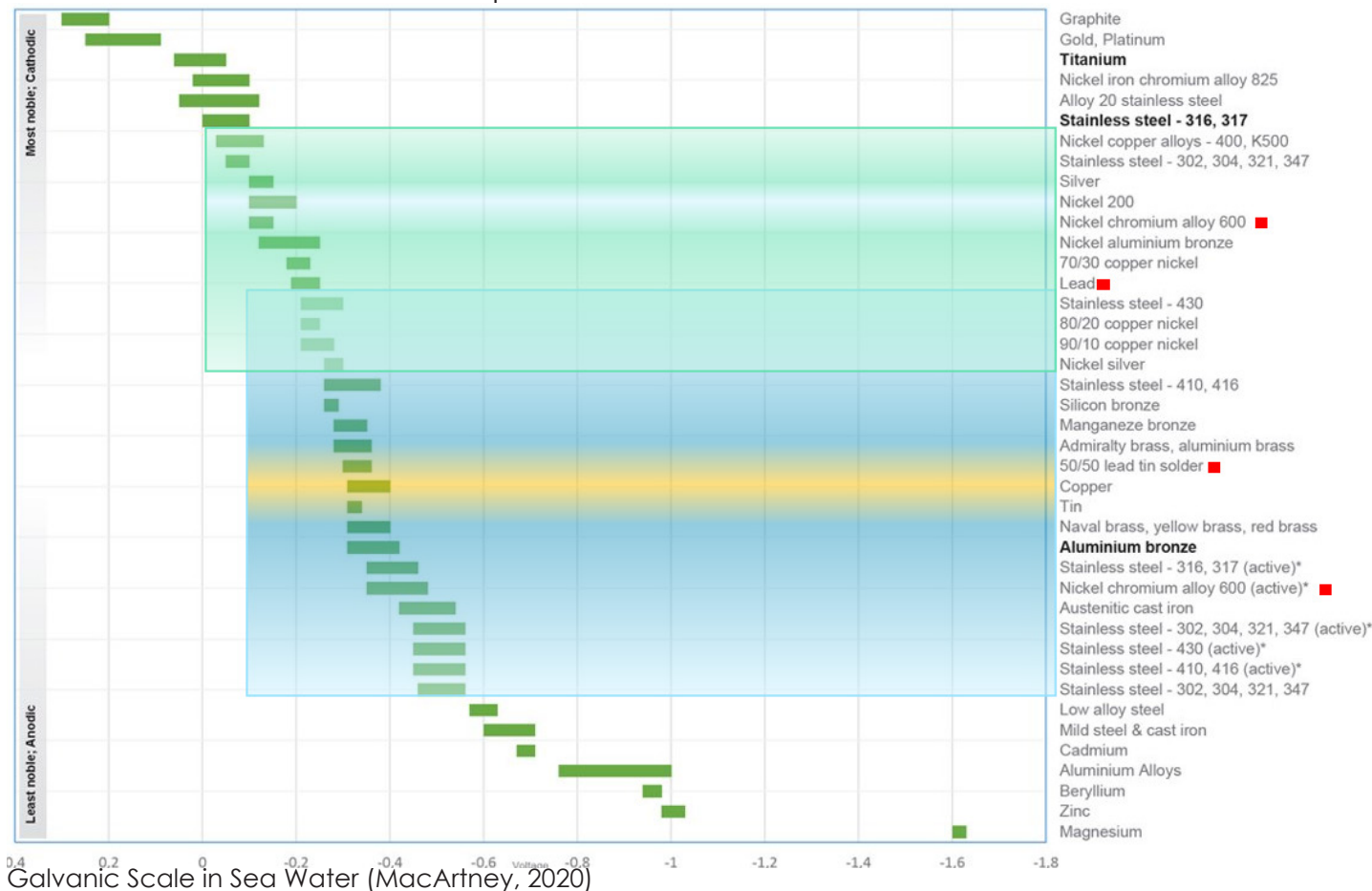


Materials Research

Metals need to be chosen carefully when working with water.

Water can be ionised, and deionised water may eventually become ionised if flowing through metal tubing. These ions can corrode metals, if two different metals are used in the same pipeline their corrosion rates depend on how far apart they are on a galvanic scale.

For caution, I am using a galvanic scale in saltwater, where the separation of materials is more exadurated. The liquid used will be distilled water.



If separate metals must be used, a voltage differential of <0.2 is recommended.

Most products on the market for liquid cooling use a nickel plated copper backplate.
*more info on page 14

Aluminium is rarely used, but if done all fittings, radiator, pump must be aluminium or plastic.



Corrosion in Radiator
(MartinsLiquidLab, 2012)

■ RoHS non-compliant

Waterblocks and Materials



Phanteks Glacier C350A CPU Water Block Acrylic Cover RGB LED - Black (Phanteks, 2021)

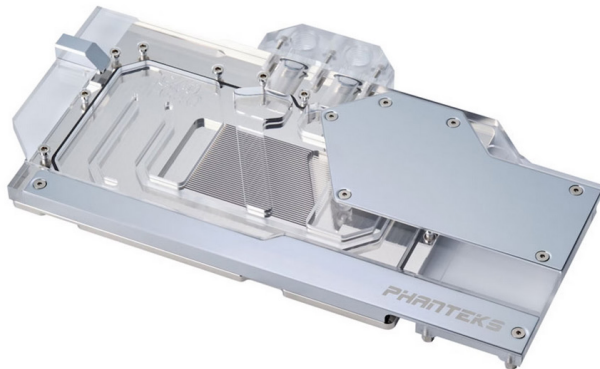


EK Water Blocks EK-Quantum Velocity² D-RGB CPU Water Block For AMD AM4 - Full Nickel (EKWB, 2021)

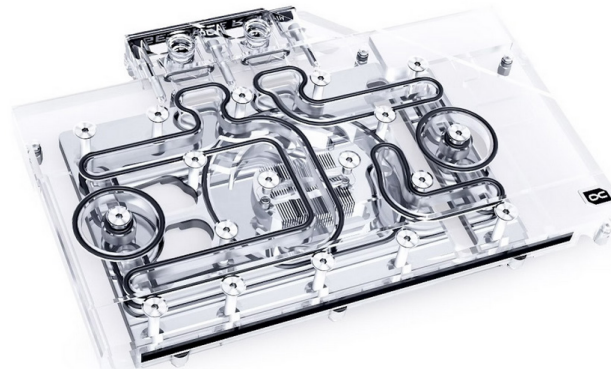


Corsair Hydro X Series XC9 RGB Black CPU Water Block - 2066 / TR4 (CX-9010009-WW) (Corsair, 2020)

Observations.
Most GPU and CPU waterblocks on the market use nickel or nickel-plated-copper. Nickel, silver and copper are all considered 'safe' to combine in desktop pipes.
There are many companies creating these cards, making upgrading for liquid cooling solutions easier.



Phanteks Glacier G40 4090 MSI Graphics Card Water Block with Back Plate - Chrome (Phanteks, 2022)



Alphacool Eisblock Aurora Acryl GPX-N RTX 3080/3090 Palit GameRock Graphics Card Water Block (Alphacool, 2020)



EK Water Blocks EK-Quantum Vector FE RTX 3080 D-RGB Water Block - Silver Special Edition (EKWB, 2020)

Heatpipes

What makes heatpipes so efficient?

Water is held at negative pressure, where the boiling temperature is lower. This causes the vapour to spread evenly and quickly at low temperatures. A mesh or grove is inside of this copper pipe to evenly disperse the small amount of water in any orientation.



Heatpipe cross-section of axial grooved, sintered and mesh.
(Alshehhi, 2019)

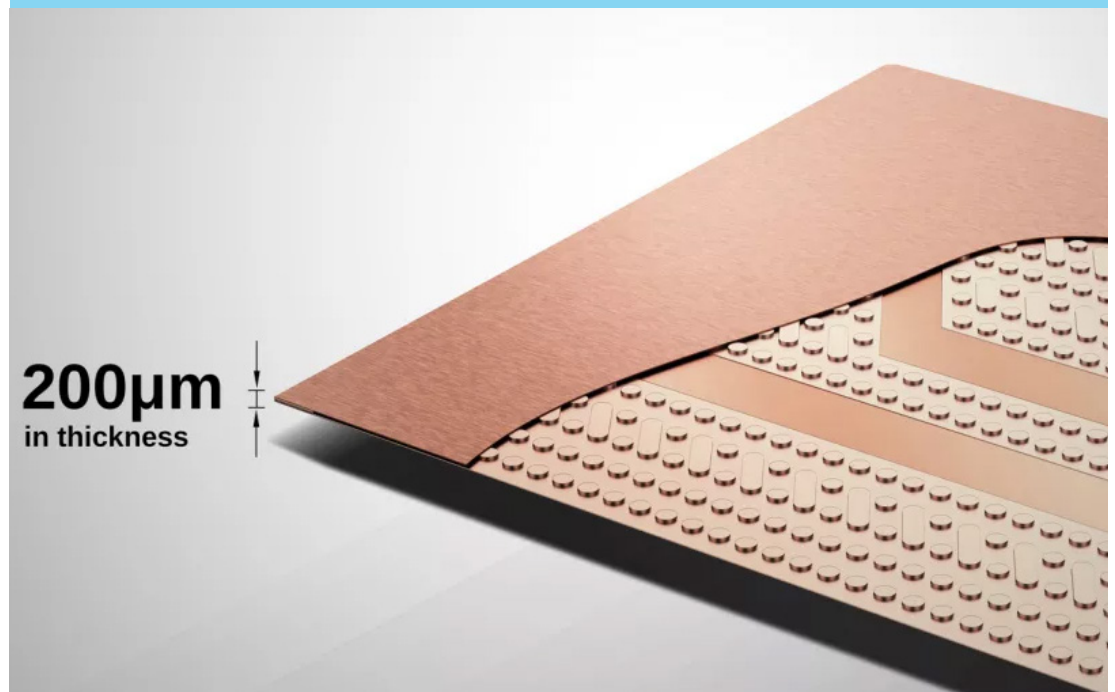
Thermal Conductivity:

- Copper Heatpipe:
10,000 to 100,000 W/m K
- Copper
413W/m K
- Nickel
106W/m K
- Stainless Steel 430
43W/m K

Pressure = Boiling point

mbar	Boiling Point °C
1000	99.7
800	93.3
600	86.4
400	75.6
200	60.5
100	45.6
1	-19.1

Vapour chambers use the same principle, but are shaped in various forms, unlike a heatpipe which is often a square or cylindrical pipe. This would be a better option for dispersing heat over a large area.



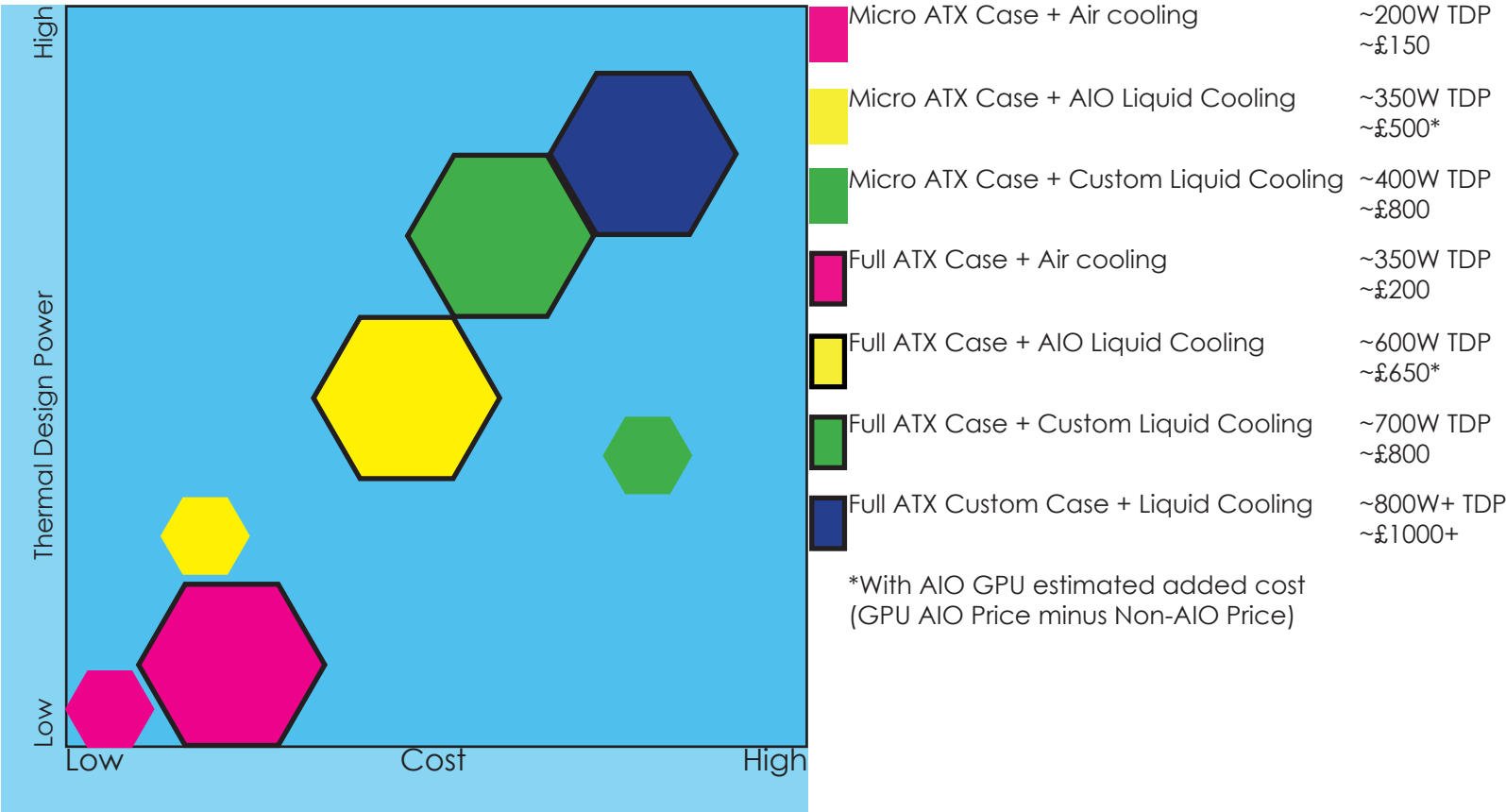
Vapour Chamber, (Cooler Master, 2021)

Market Analysis

Research on estimated costs and thermal design power (TDP) of current on the market cooling solutions and case costs. These costs do not include any computer parts other than the case and cooling equipment.

AIO (all in one) are preassembled liquid cooling solutions users can buy. CPU blocks can be purchased however, GPU AIO kits come with a pre-installed GPU, I have subtracted the cost of the GPU to give an estimated added cost of making it AIO.

Custom liquid cooling includes, radiators, pumps, fans, resevoirs and water block for GPU & CPU.



Market Analysis Page 2

Price Filter



Prebuilt Watercooled Systems prices.

Research conducted looking at costs of components of liquid cooled machines and subtracting the component costs to the PC cost. This gives an idea of the cost of liquid cooling and cases. From this research, I can locate an area in the market to break in at.

From the conducted study, I would like to make a case and cooling system for >£2,500. To keep it upgradeable this cost doesn't include waterblock prices, which will add another £200-£500

Mid-range Custom (Overclockers, 2021)



Spec Costs
3600MHz DDR4
16GB: £80

Ryzen 7 5800X3D:
£380

RX 7900 XT Gaming
20GB: £820

1.5TB M.2 + SSD: £130

**OcUK Gaming Osprey -
AMD Ryzen 7 5800X3D,
RX 7900 Series Gaming PC**
FS-1FR-OG

Asus TUF Gaming
X570 WIFI: £140

850W 80Plus
Bronze: £75

£2,399.99 (incl. VAT)

● Built to order

CONFIGURE

Component Cost:
£1,553

Cooling, Case &
Build Cost:
£846.99

Mid-range Custom (Overclockers, 2022)



**8Pack Cryocube - Intel
Core i9 12900K Extreme
Overclocked PC**
FS-00L-8P

£8,888.88 (incl. VAT)

● Built to order

Spec Costs
6400MHz DDR5
32 GB: £320

i9 12900K: £450

3090 GPU: £1300

2 x 2TB SSD: £350

Asus ROG Z690
Maximus: £660

Asus ROG Thor
1200W: £370

Component Cost:
£3,450

Cooling, Case &
Build Cost:
5,438.88

High End Custom (Overclockers, 2022)



**8Pack Supernova - AMD
Ryzen Threadripper
5995WX @ 4.0GHz DDR4
Extreme Overclocked PC**
FS-001-8P

★★★★★ (1)

£21,888.88 (incl. VAT)

● Built to order

Spec Costs
8 x 32gb DDR4: £1,560

Threadripper Pro
5995WX 64 Core:
£6,500

2 x 3090 24GB: £2,600

6TB SSD 14TB HDD:
£1,550

ASRock WRX80 Crea-
tor ATX: £900

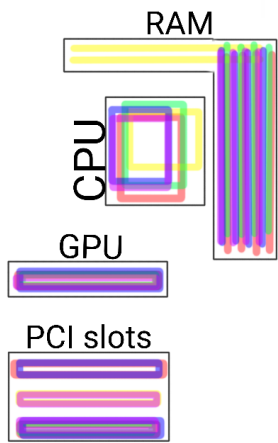
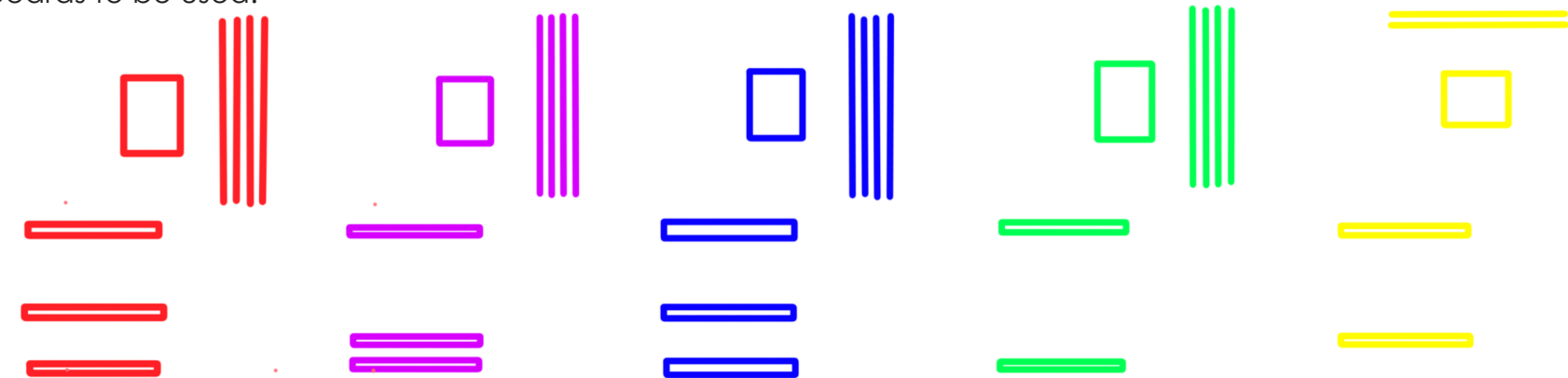
850W 80Plus
Bronze: £400

Component Cost:
£13,510

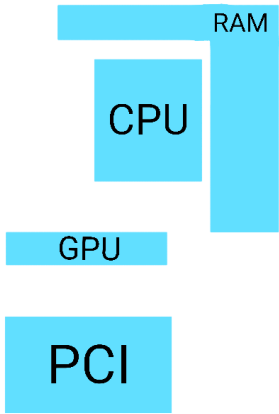
Cooling, Case & Build
Cost: 8,378.88
£846.99

PC Constraints

Here I have sketched outlines of all the extruding components and their locations to allow for a more accurate design outcome. These different orientations are inportant to allow fo a wide veriety of moth-
erboards to be used.



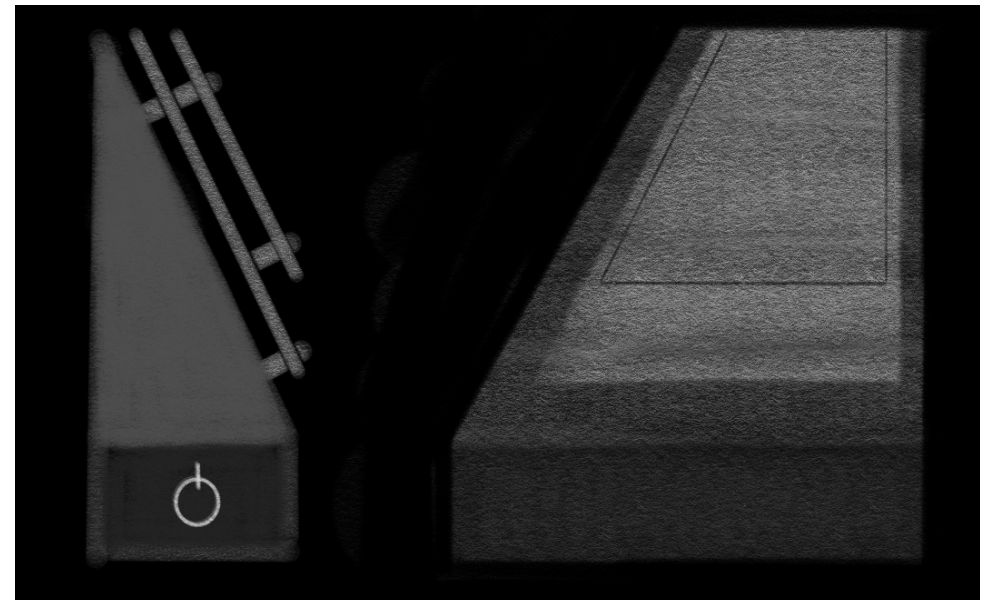
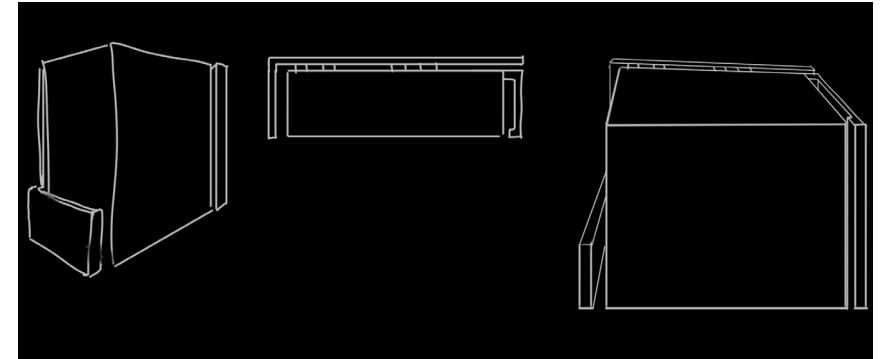
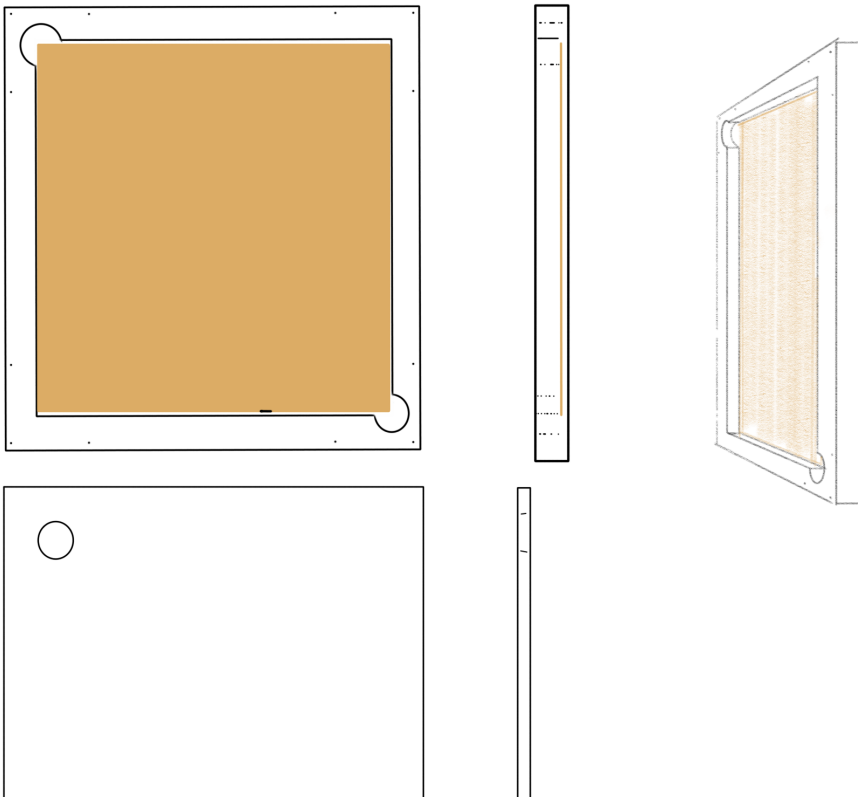
- Asus ROG MAXIMUS Z690 FORMULA, LGA 1700
- Z690 AERO G
- Z690 TOMAHAWK
- ASUS ROG Strix Z690-G
- EVGA Z690 Dark kingpin



Concept 3

Design a desktop with a full vapor chamber water 'loop'. Designed so the water is funneled to the processors where its heated to boiling (at negative pressure) and enters the cooling chamber condensing it back to a liquid in another section which goes to the processor inlets.

This method would require a vacuum to be formed after assembling the parts, allowing the vacuum to be in the liquid tubing



Pump research

Higher = Better	Lower = Better	
% Vacuum	mbar/hPa	mmHg/Torr
20	810.60	608.00
40	607.95	456.00
60	405.30	304.00
80	202.65	152.00

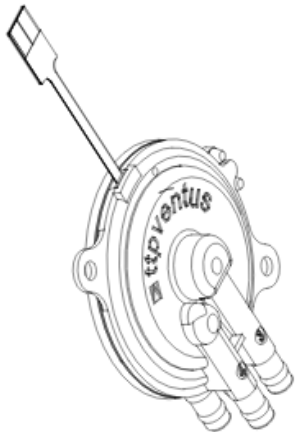
Researching through the web for a day, I found no small pumps able to create a vacuum that wouldnt greatly affect the designs size or be problematic with sound



Cheap Diaphragm Pump
~£1 to £5
Max pressure ≤560hPa
Lifespan >500 hours
(Alibaba, 2022)

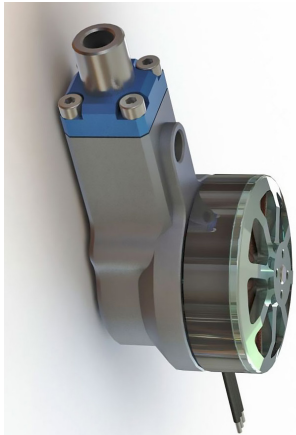


Mini Diaphragm Pump
~£30 to £80
Max pressure ≤470hPa
Lifespan >5000 hours
(Changzhou Jiebei Fluid Technology Co., 2022)



Piezoelectric Pump
~£???

Max pressure ≤400mbar
Lifespan ? hours
(TTP Ventus, 2022)

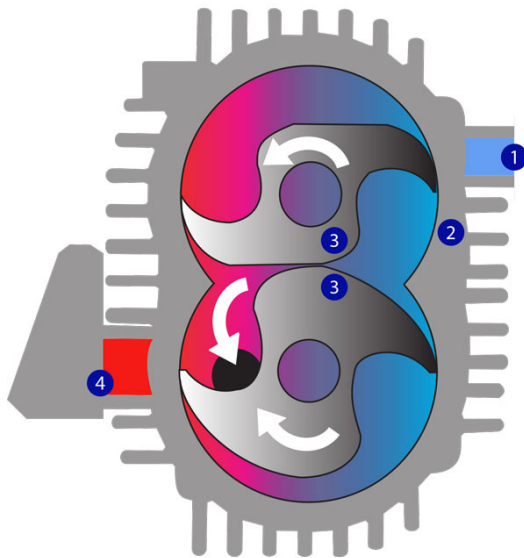


Mini Piston Pump
~£400
Max pressure ≤80% vacuum
Lifespan >10000 hours
(Micro Pumps, 2022)

Extended Pump Research

Through this further research into more advanced pumps,

Claw Pump

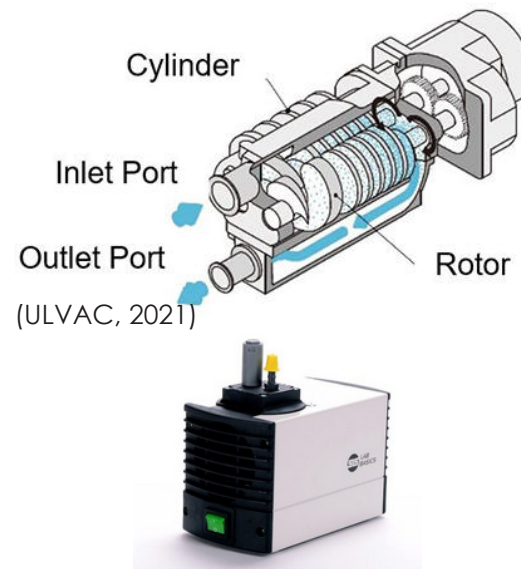


Working Principle: Claw pumps rotate creating negative pressure on one side and positive pressure to the exhaust.

Benefits - Strong Vacuum

Problems - Complicated maintenance, High Cost, Large.
(Republic MFG, 2020)

Screw Rotor Pump



(SLS Labs, 2022)

Working Principle: Two screws spin and force air through them.

Benefits - Lower Maintenance, Strong Vacuum

Problems - Many Parts, High Cost, Large.

SLS Labs ABS pump for £400, ultimate pressure is 100mbar.

Screw Rotor Pump



(Schwenke, 2018)

Working Principle: One moving scroll rotates around another, compressing the air to the center.

Benefits - Quiet, Strong Vacuum, Efficient

Problems - Very Expensive, Large, smaller life cycle

Secondary pumps:

A secondary pump is used to help further a vacuum by pushing air towards the primary pump. There are many types of these pumps, this includes:

Gas Transfer

- Turbomolecular pumps

- Positive Displacement Pumps.

Entrapment

- Ion Pumps
- Cryo Pumps

DIY Solenoid Pump

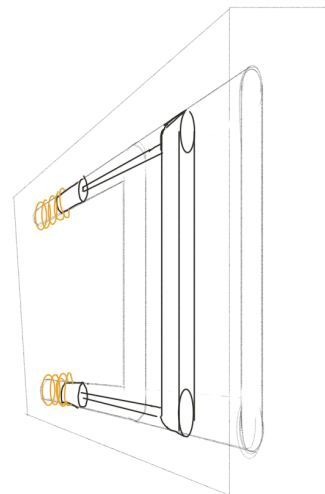
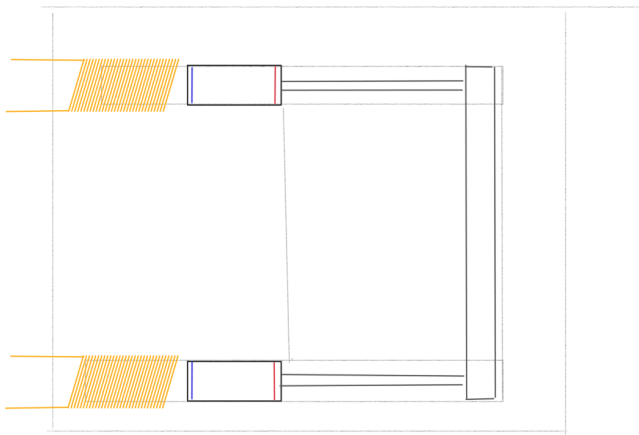
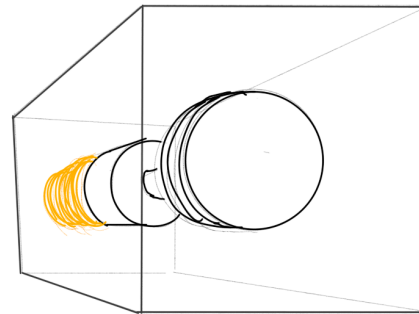
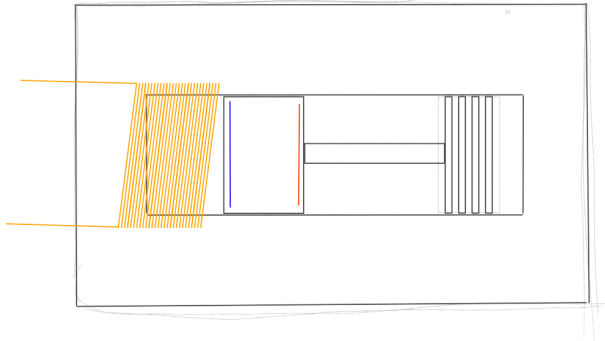
To avoid the high cost of one of the advanced pumps that would bring me to the pressure that would make water boil at low temperatures, I tried to think of an alternative concept. Using the solenoid as a high power

This would use O-rings to create an airtight seal on one end, this is attached to a solenoid.

The coil for the solenoid would turn on, forcing a vacuum to be pulled.

This system will require a powerful pull due to the friction of the airtight seal and the force of the negative pressure pulling it into place.

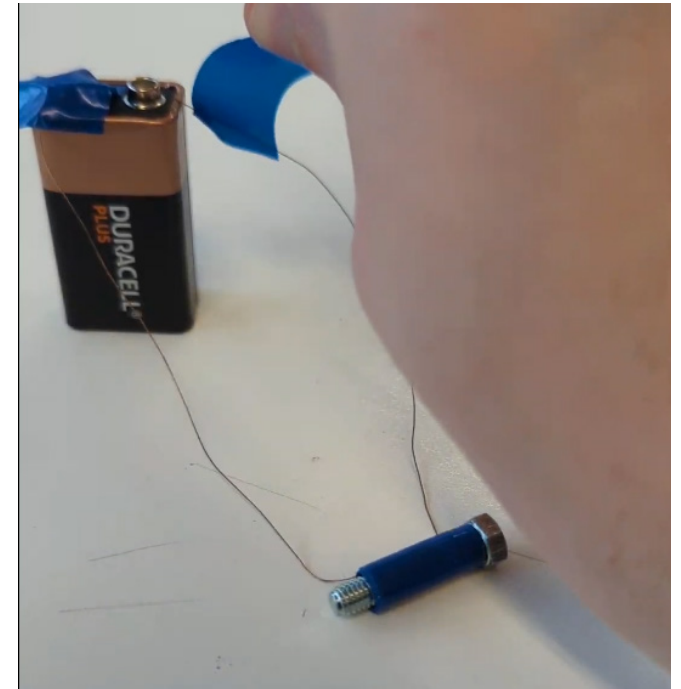
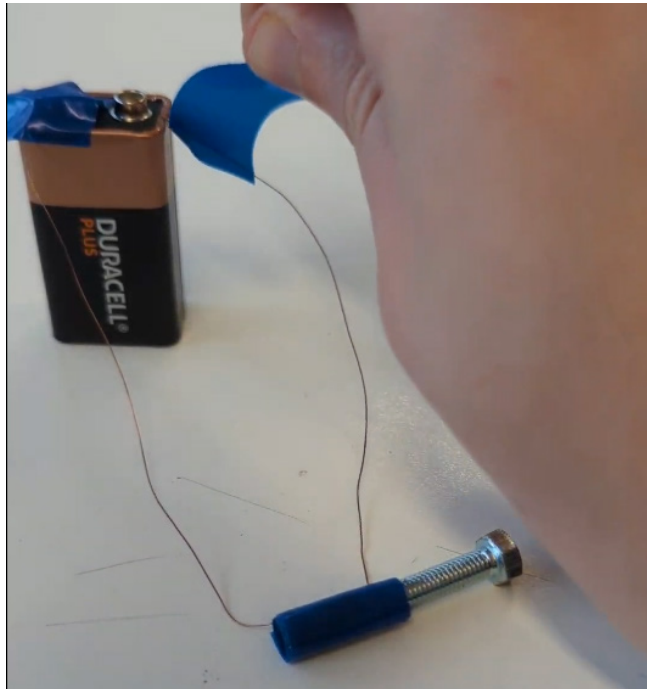
A locking system should also be designed to avoid needing to supply the solenoid with constant power.



Solenoid Pump initial tests

Solenoid experiment was effective. For this test I used 40 coil winds around a screw. I then removed the coil windings intact and placed them in front of the screw. I used a 9V DC battery to connect the wires.

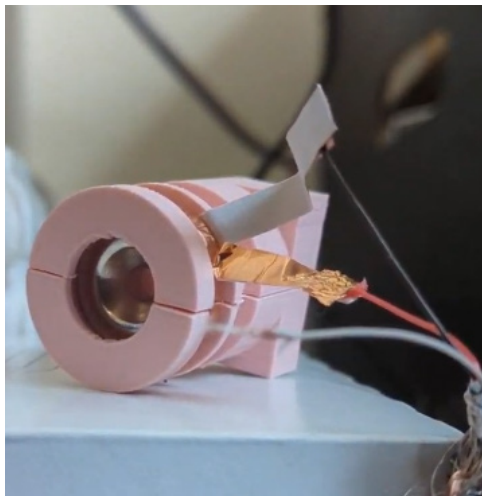
Initial problems - Wire got hot at lower coil winds and melted the tape. 20 winds seemed to have no effect, assuming that more winds means more magnetic attraction.



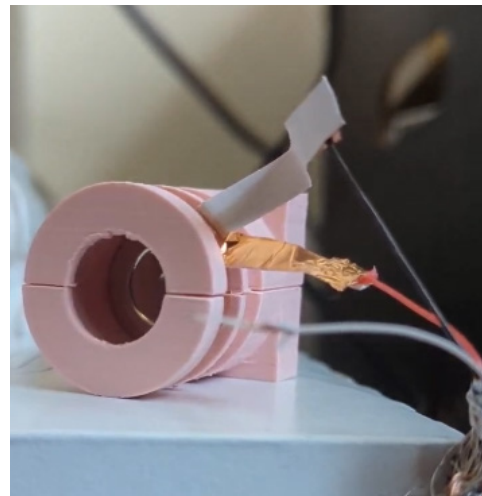
DIY Solenoid Pump + Magnet

The principle of the solenoid was affective, yet very weak. I read to increase this you can use stronger magnets along side the electro-magnet for higher force.

To test this I bought two magnets, a SmCo magnet and Neodymium magnet, both with 12kg magnetic pull.

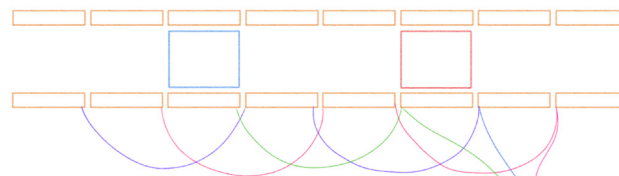


Coil powered off, magnet between coil.



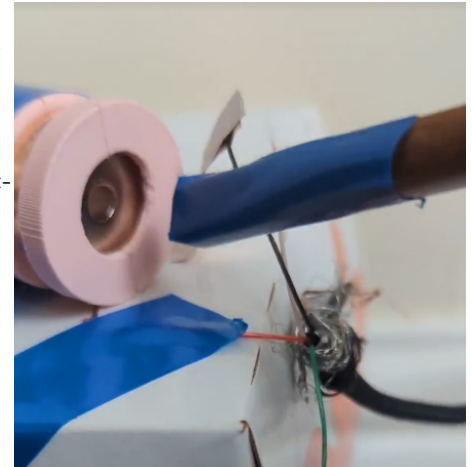
Coil on, magnet repelled from coil

I created a coil around a 3D printed chassis to hold the magnet in place during testing. I used 5V at 1A through the coil to see the results.

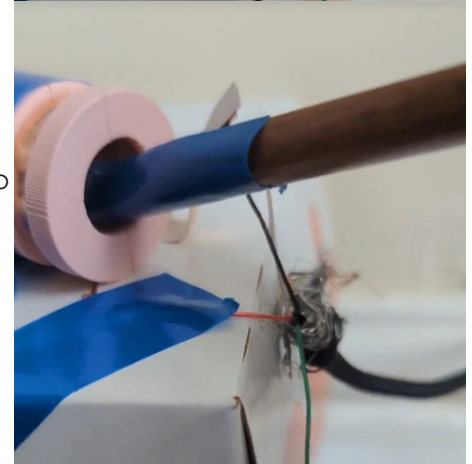


This model gave me the idea to create a linear motor, while some exist they use a slightly different principle to this. I decided to leave this research path. It would require me to use more electricity than I would be comfortable working with. While the path had validity, I decided to go a safer route and continue looking for pumps.

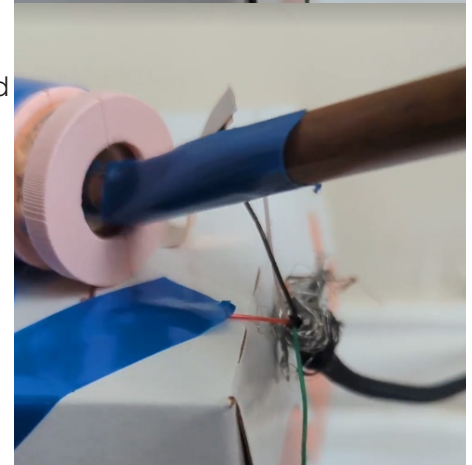
I turned the magnet around so it was now attracted to the coil. I then used a poking device to test the strength of the attraction to the coil.



It was significantly stronger than the previous attraction but only took a force of aprox 50g-100g to move it away. Far too weak for a solenoid vacuum.



The magnet quickly bounced back into place once I stopped applying pressure



Magnets colided, the SmCo was brittle and shattered.

Concept 3 Update

This update looks at removing the water pump and replacing relying on convection and gravity to transport the water where it needs to be.

The benefits if this works:

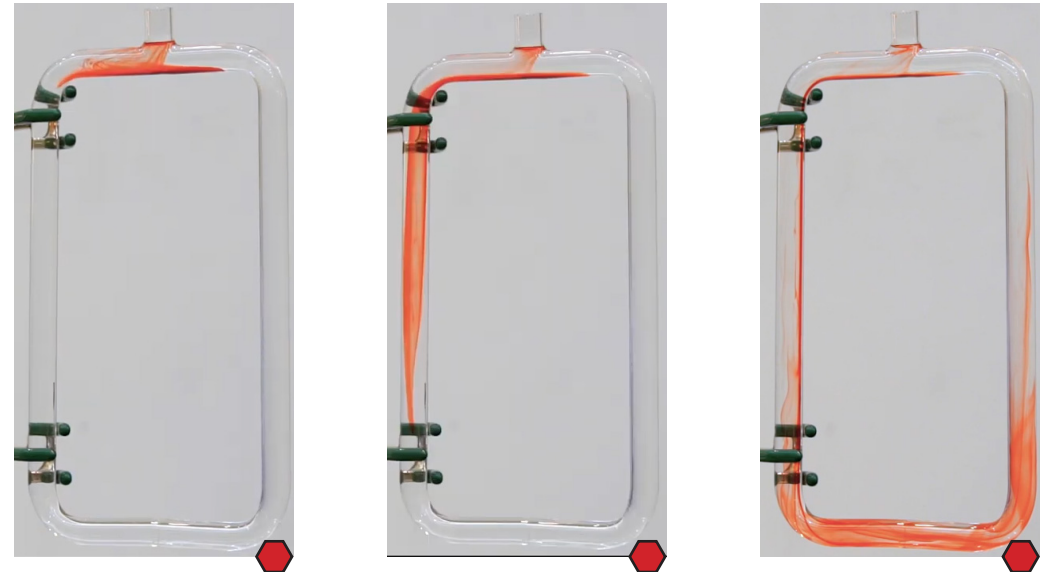
Less energy used

Lower noise



Iron with removable water tank (Panasonic, 2020)

Convection current have been demonstrated in water loops previously, the images below are taken from the YouTube channel 'Physics Demos'.  =Heat source



Further additions to this update:

I would like to add a detachable water tank allowing users to feel at ease by keeping open liquid away from their machine.

This should feature a sign that is a universal indicator not to fill with tap water - these systems should be filled with distilled water.

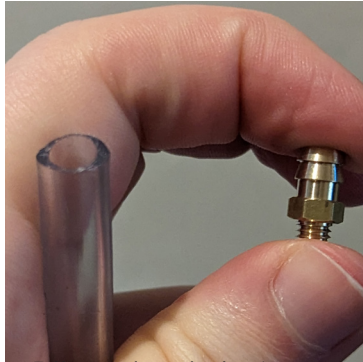
An example of such an icon:
A QR code could be used too, allowing for many languages.



Fittings



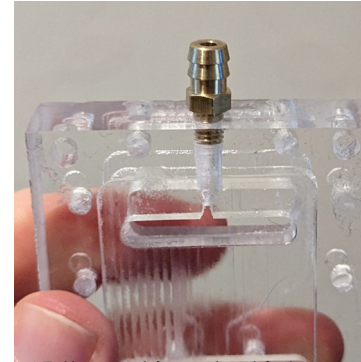
Vacuum non-return valve. Did not find effective at holding a vacuum.



M5 thread male to 6mm barb. I use this in prototype tests.



Barbed end into hose connected to vacuum.



M5 thread inserted into version 2 prototype



1/8 in Female BPSS to 7mm barb. This end was used in vacuum generator.

Dependant if flexible tubing like this is viable for pressures <50 mbara, I would likely incorporate them into the design for quick and easy maintenance. While they have worked fine for pressures around <300 mbara (as long as there are no kinks in the tube), this may not be the case in higher vacuums.

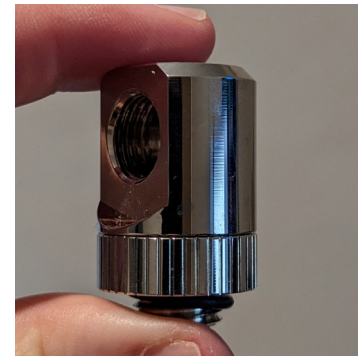
A similar problem may be present with the soft 10/14 tubing I tested, however I have found reinforced vacuum hosing in this size which should work.



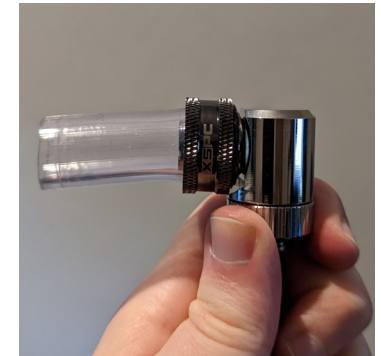
10/14 compression fitting to 1/4 thread. This is ideal for use in PC liquid cooling loops.



Once fitted, I was unable to remove it, even when unscrewing the compression fitting.



1/4 female to male rotary fitting, can swivel 360 degrees.



Compression fitting attached to swivelling fitting allowing for adjustability.

Fittings Page 2

Looking at fittings for quick attachment and disattachment, allowing for users to easily access the water tank to refill. These fittings allowed for a quick removal with a good air tight fitting. They are hard to remove with force unless you push on the blue tube connector. I will be using this type of connector in the finished design.



Elbow fittings for metal tubing have a strong hold when tested, however I have not yet tested them under negative pressure. this will be done at a later time.



Before pushing onto copper pipe.



After pushing onto copper pipe. - Note blue plastic is pushed to brass fitting.



Applying force to try and push off brass fitting. It did not move at all.



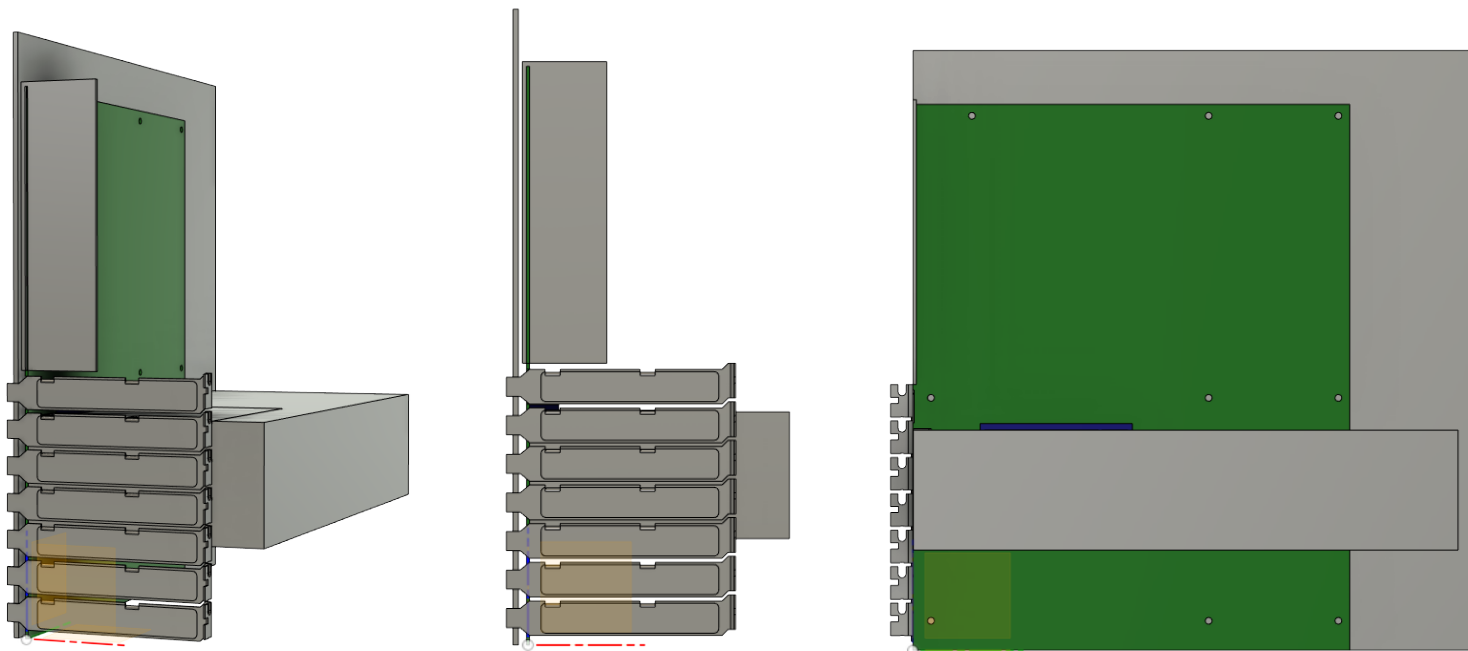
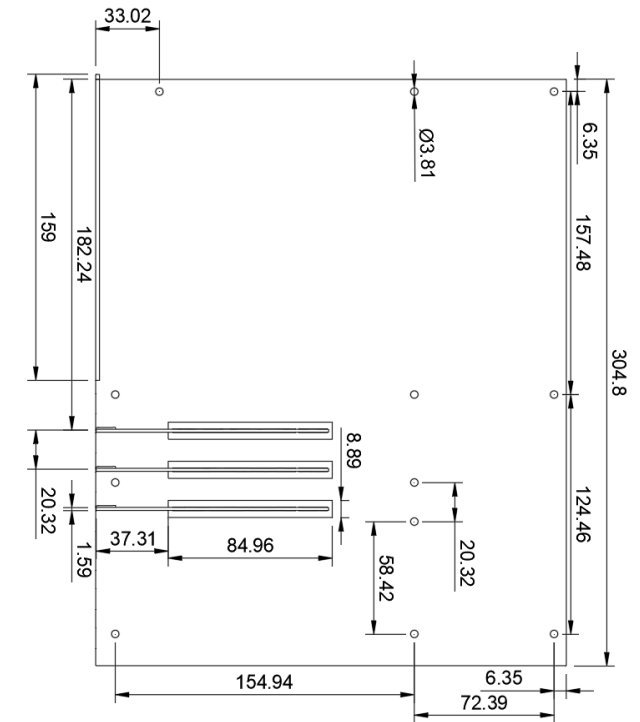
When force applied to blue plastic it quickly comes off, leaving a score mark on pipe. (will this be okay after multiple removals?)

Fusion Desktop Components

I accurately modeled and created engineering drawings for ATX motherboards, I included micro ATX holes which some ATX boards also use. I also incorporated all PCIE expansion slots, IO Shield, GPU (to scale of 4090 largest consumer GPU on the market), And distance to mounting bracket.

This will allow me to design accurately around the board.

I have not included the power supply unit as this could be mounted in a wide variety of places as its not rigidly bound to the motherboard. I will need to create a template of the hole and power cut-outs of a PSU.



Pump Update

After further research for pumps I came across a scroll pump, after discussing with the Director of Engineering for Scroll Labs, I have found two pumps that fit the dimensions for my project.



5lpm vacuum (Scroll Labs, 2022)

Pump speed: 5lpm
Power Consumption: 20W
Noise Level: 56dB(A)
Dimensions: 186×132×119mm
Connectors: G 1/8"
Temperature Range: -40 to 50°C
Cost: \$1537

After careful consideration, I decided to go for the 2lpm scroll vacuum. The reasons for this are:

- Lower cost
- Quieter
- Smaller
- Less power

I calculated the evacuation time on the 2lpm pump for a 500ml chamber, It will reach <50mbara in less than 54 seconds.

Update (after prototype testing): This pump has been ordered and will arrive for testing in the next term of the final major project. I will also be designing a 500ml or less tank to test this pump with.



2lpm vacuum (Scroll Labs, 2022)

Pump speed: 2lpm
Power Consumption: 6W
Noise Level: 45dB(A)
Dimensions: 50×50×64.5 mm
Connectors: M5x0.8
Temperature Range: -40 to 50°C
Cost: \$1195

Sustainability

I have chosen to go for a 6W Scroll vacuum pump. The main reason for this is the wattage of this pump.

A standard 120mm desktop fan uses 1.8W running at a normal speed, this can go up to 12W depending on the brand and if its at full speed. With a normal midrange to high end case using 5+ fans, this is 9W. On Page17, the cheapest desktop uses 5 fans, the mid range and high end desktop use 8 fans, this totals 14.4W.

These PCs also have 1 - 2 water pumps in them, these use 5 - 25W each.

If convection can be a possibility for transporting the water, the desktop can effectively cool at no more than 6W compared to the high end desktop, which takes 24.4W minimum, or 220W if everything is maxxed out.

Less plastic is also needed, as the fan blades and mounts are rarely made from anything else other than plastics, the small amount of singular metal milled to, the only plastic being in the electronics.

Considerations:

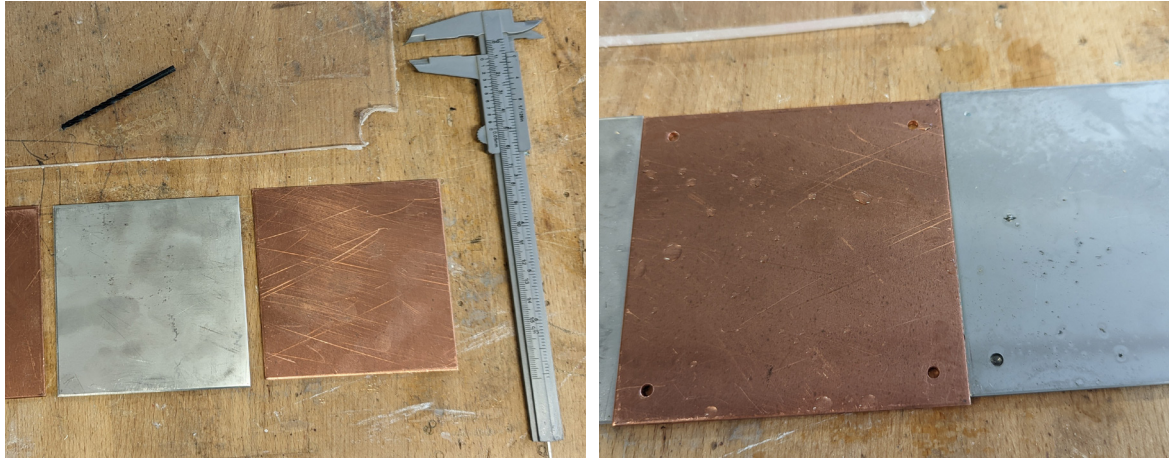
Milling takes up a large amount of energy

The average lifespan of a computer is between 3-8 years according to HP (HP, 2022).

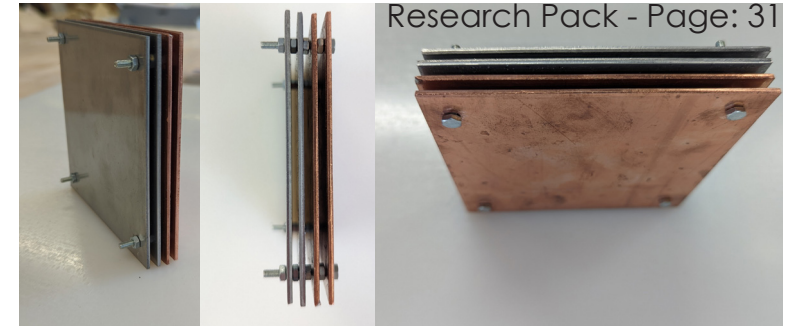
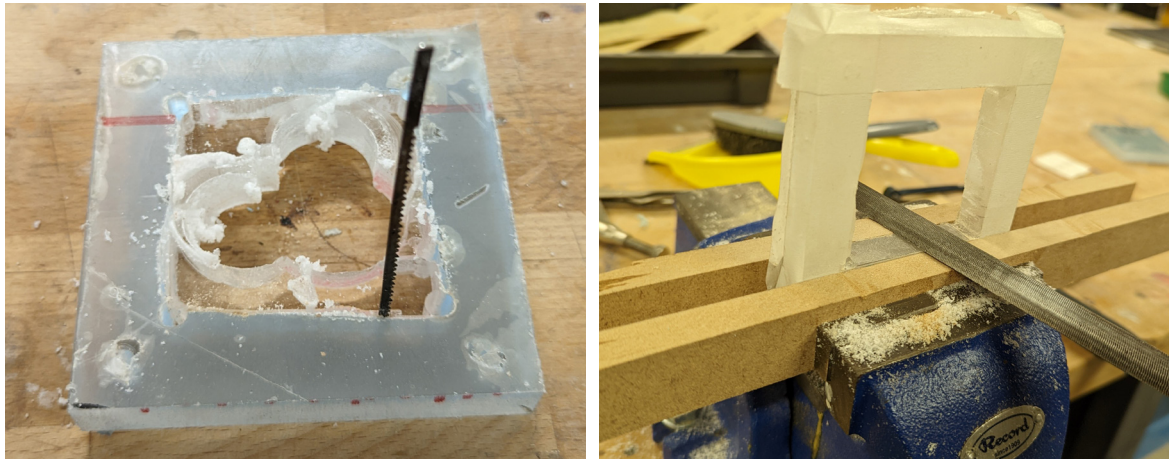
While this desktop case is designed to last many generations of technology, conciderations should me looked at to the worst case scenatro where the system is only used for 3 years. Is the energy used to make the machine outweigh the current design of desktop cooling systems.

Building a Test Chamber

Drilling

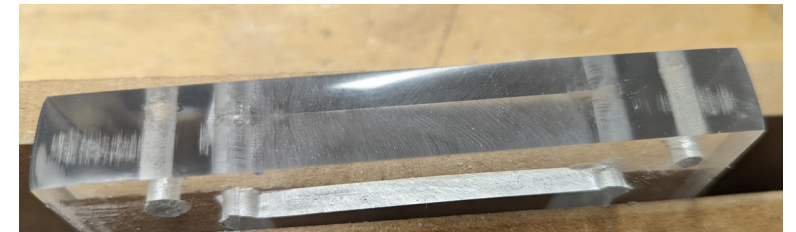


Cutting & Filing



Checking Alignment

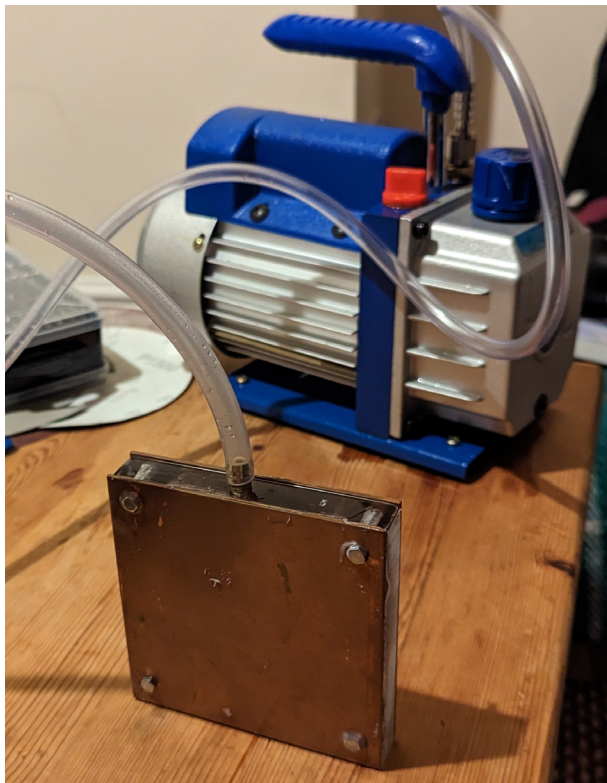
Sanding & Polishing



The final stage of this was going to be making silicone washers to prevent air gaps, but I didnt want to waste time so I brushed silicone between the gaps and assemblies while the silicone was wet. hoping it creates an airtight seal.

Principle Testing

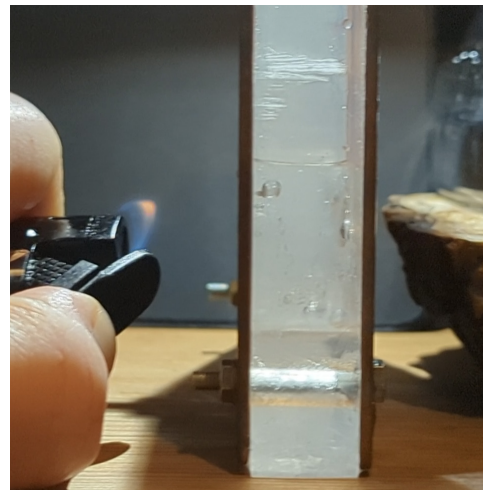
While there is already a large quantity of evidence that supports the theories behind my design, I wanted to try and achieve this while I waited for the scroll pump to arrive. This cheap rotary vane pump claims to be able to pull a vacuum of 0.5mbara, which is more than enough for this test.



In the first 2 minutes the air trapped in the water was pulled out



About 4 minutes in the water began to bubble.



I tried heating up the copper plate with a lighter, the water boiled slightly on the left side.

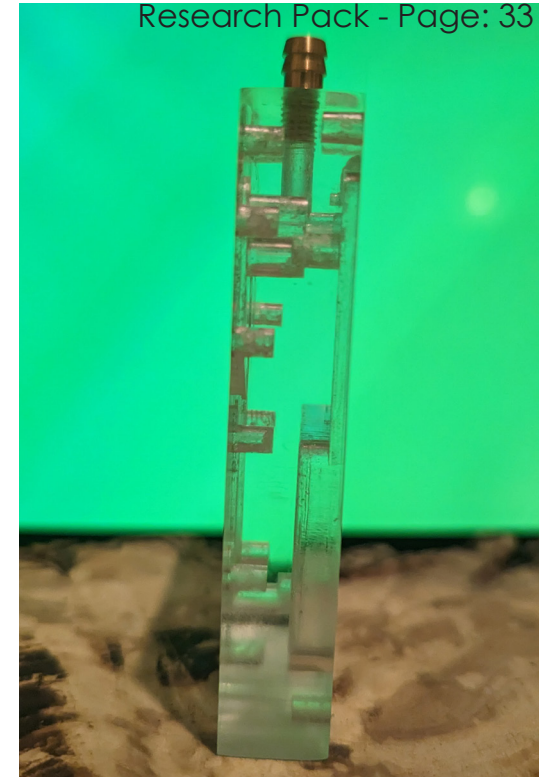
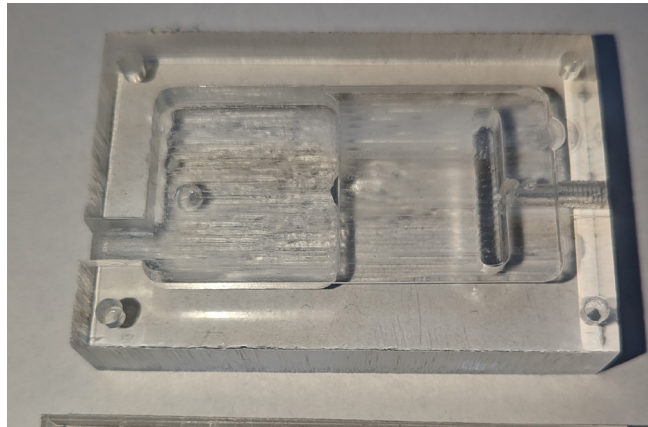
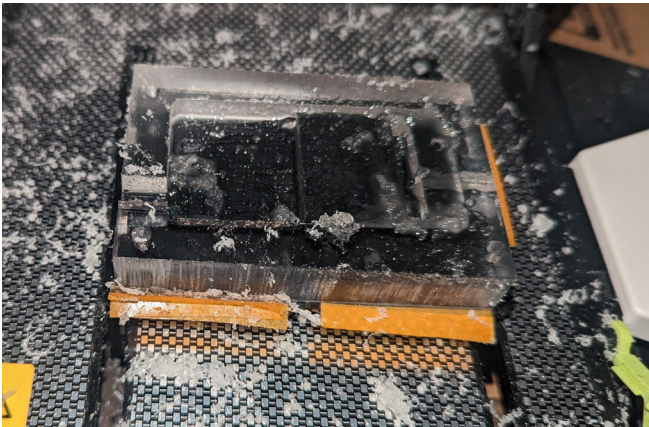


shortly after heating up the side I noticed it was bubbling slightly more rapidly.

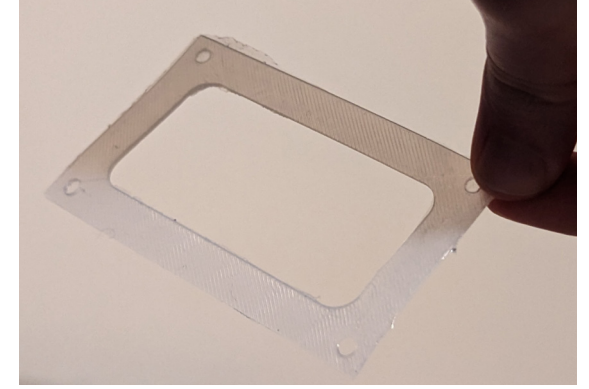
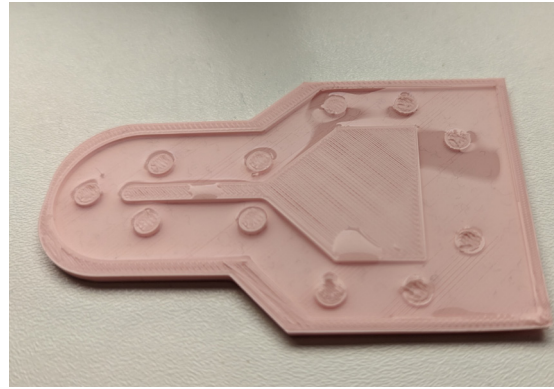
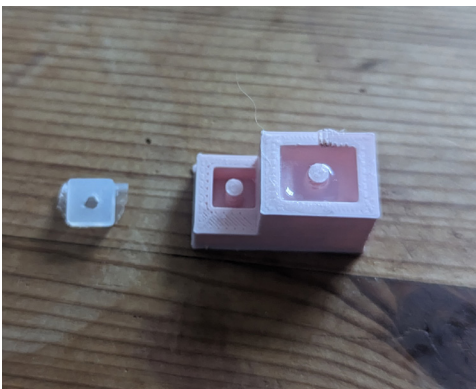
This attempt wasn't as effective as I thought it would be. I measured the temperature but there were no fast or highly noticeable changes. the copper stayed at around 15°C until I held the lighter to it for about 10 seconds, it then peaked at 17°C before dropping.

Creating an advanced prototype

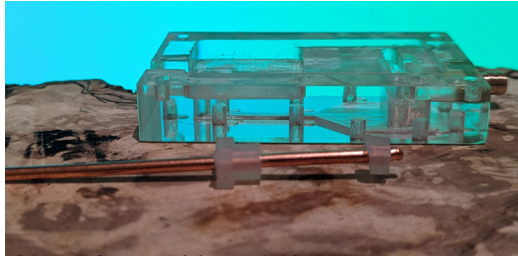
I wanted to create a prototype after the chamber I made previously didn't give me all the results I required. This prototype was milled from Plexiglass, taking 12 hours to complete both sides on a roland imodela.



I 3D Printed molds to cast silicone washers in to prevent air entering the chamber, also making this one upgradable by not using adhesive.



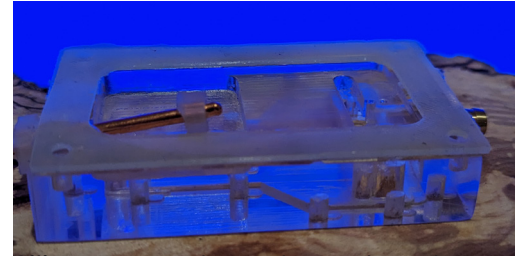
Prototype Assembly



Chassis and heatpipe



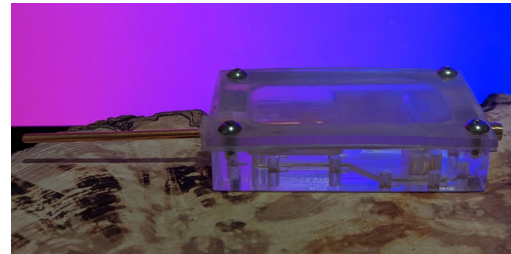
heatpipe in chasis



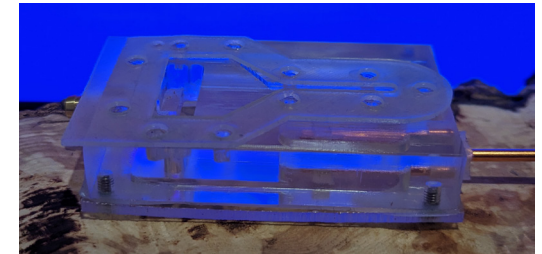
Silicone washer placed on top



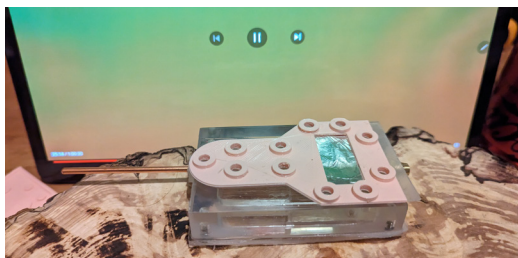
acrylic top plate placed



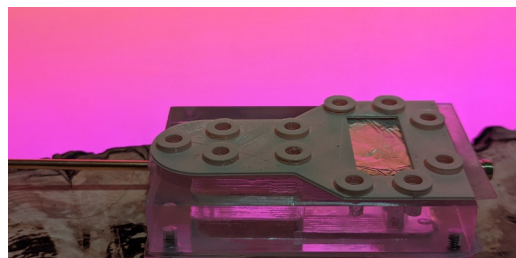
acrylic top plate screwed in



Flipped and washer placed



metal foil and 3d print placed

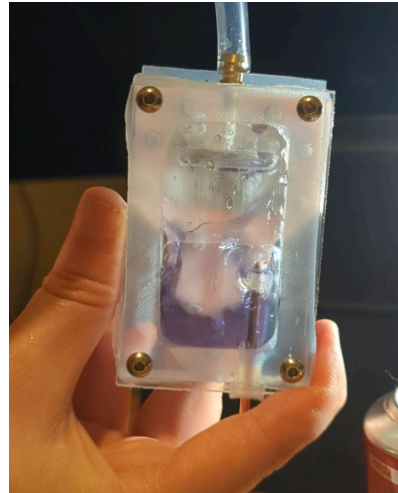
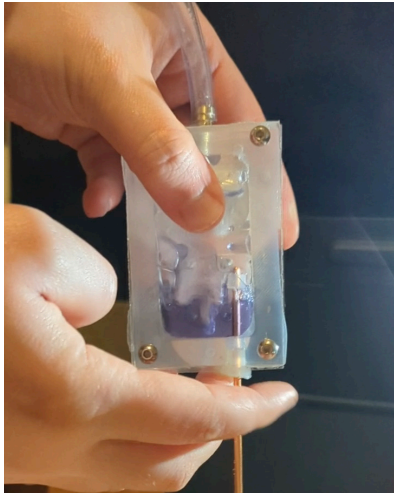


3d print placed close up



screwed in

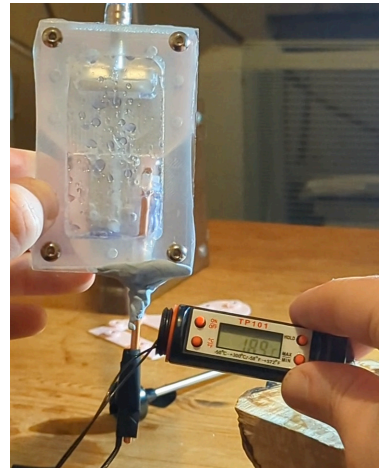
Testing advanced prototype



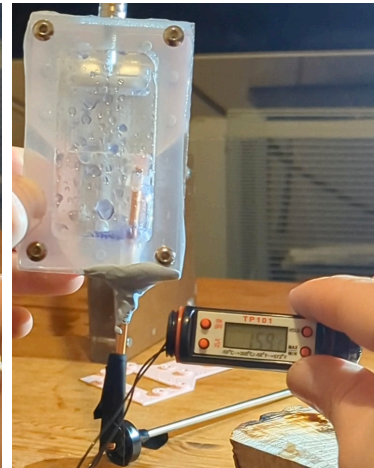
First test:
Rapid bubbling from heat pipe, considered there may be a leak. I tried to wrap it in tape, seal it with bluetac to see if that would stop it. It had no effect. I drained some liquid out as I didn't want it going into the pump. I submerged it and pulled a vacuum to see if there was a leak, but there wasn't.

This led me to believe this was not a leak. The device was working more than expected. I had to use significantly less water due to the aggressive boiling. Watching the video back, a large amount of air was forcing through from the foil side to the water reservoir. I imagine this is due to the vaporisation of water on the foil.

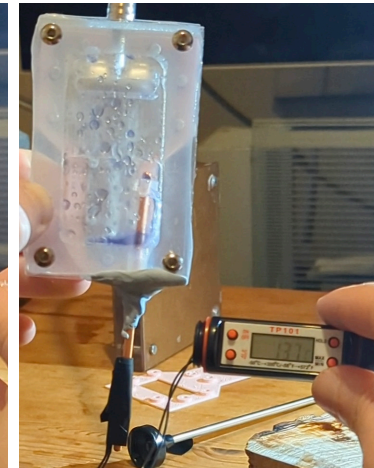
After the initial test I felt the heat pipe and it was very cold. I was curious to how it would perform without a heat source placed on it. To my surprise, this doesn't just remove heat very quickly, it drops below ambient temperatures. In this 2 minute film the temperature gauge, directly taped to the heat pipe, dropped 4.2 degrees below ambient.



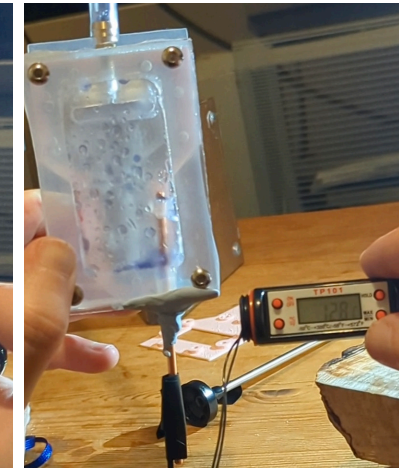
5 seconds in 18.9°C
(17°C was ambient)



30 seconds in 15.9°C
(17°C was ambient)



60 seconds in 13.7°C
(17°C was ambient)



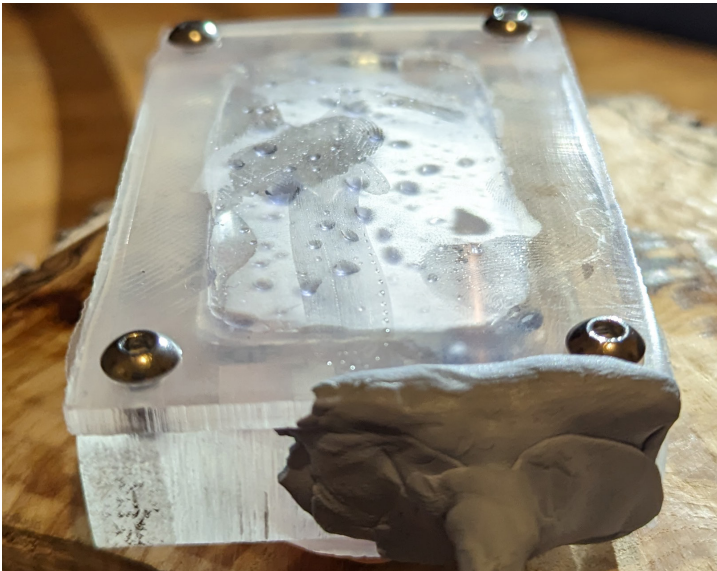
120 seconds in 12.8°C
(17°C was ambient)

Research Pack Conclusion

The research conducted, both secondary and primary have shown better than expected outcomes of using a full vapour chamber as a cooling unit. This has shown not only to cool down but to do so at sub-ambient temperatures.

Furthermore, most high end pc systems use a combination of fans and pumps to cool down components. If convection cooling can be used, this PC case and cooling solution can work at $<6\text{W}$ of electricity. Cases with a single AIO CPU liquid cooler, already use $>7.8\text{W}$ for the pump, not including the potential 3 fans that may go with it.

Condensation on outside of plastic case, showing that inside is colder than ambient.



Next Stages

Design a larger scale prototype.

Consider using a single pipe or similar concept where potential for air leak is much less.

Test cooling on heating elements.

Integrate case and cooling system to cohesive design.

Explore user interactions and make adjustments.

Ensure condensation doesn't form on tubing - Could form water droplets and damage components.

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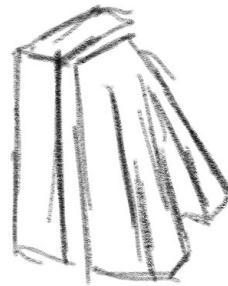
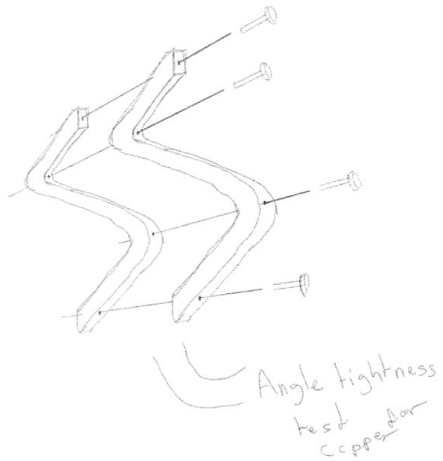
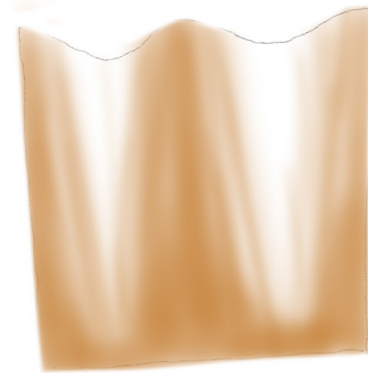
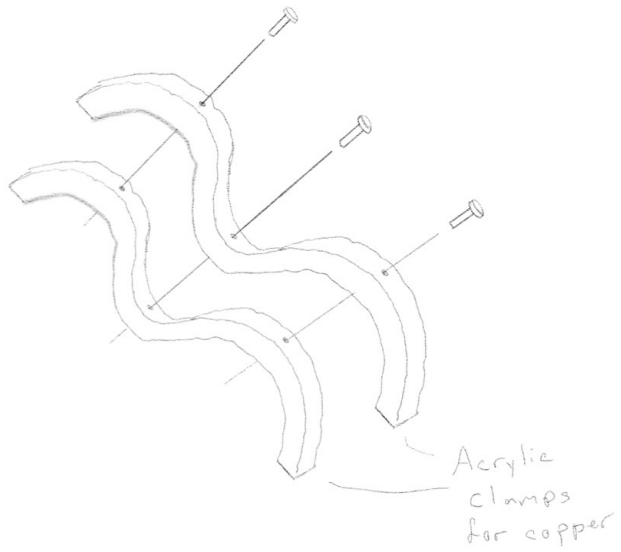
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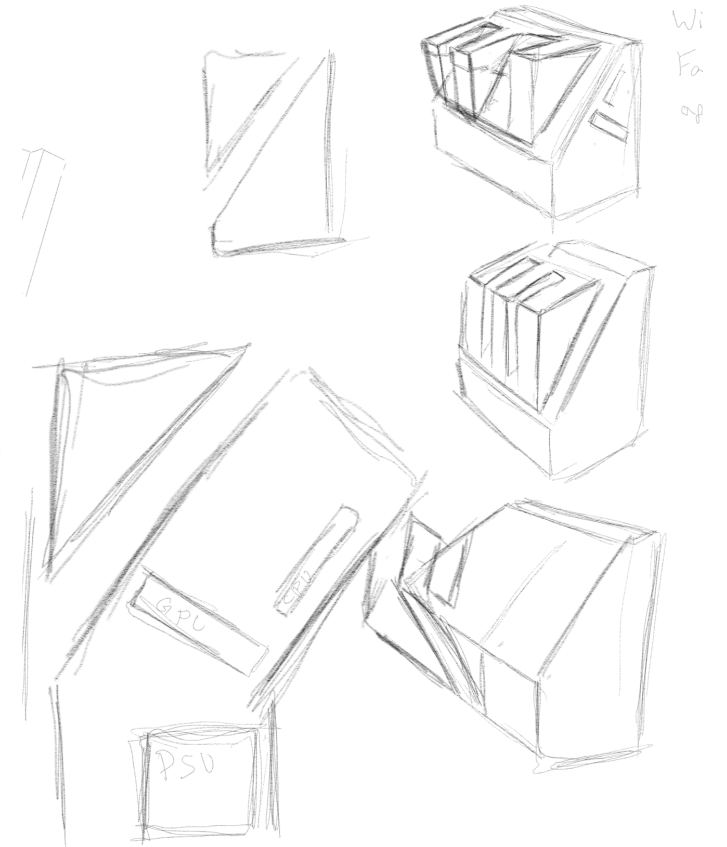
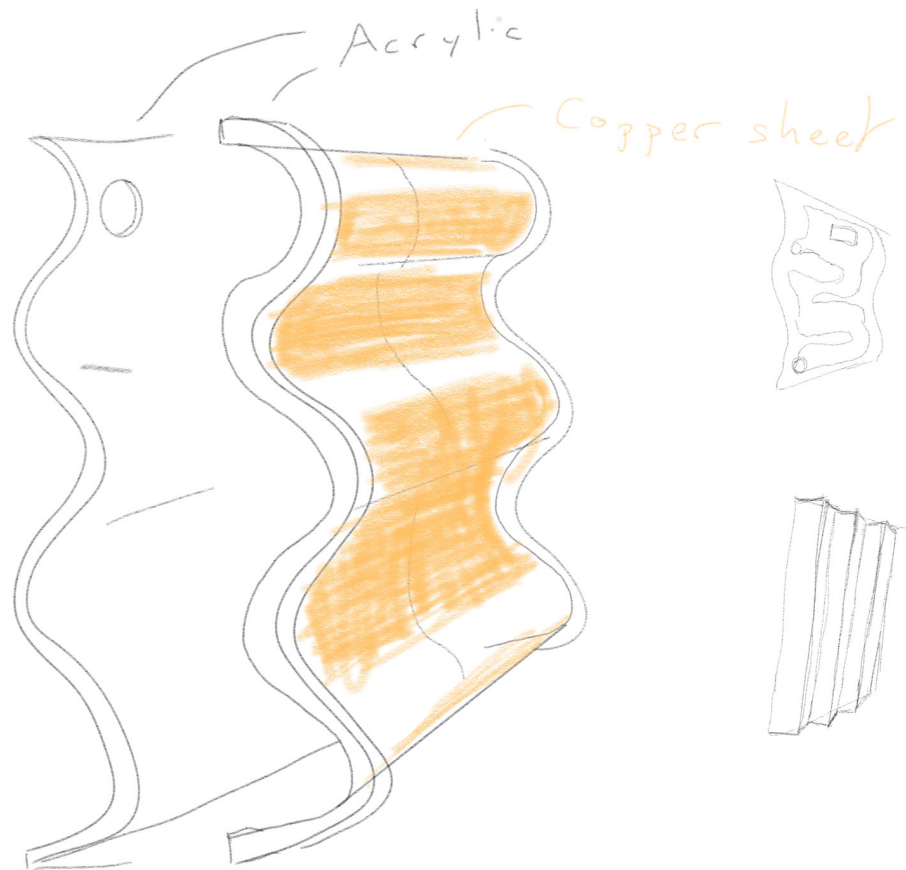
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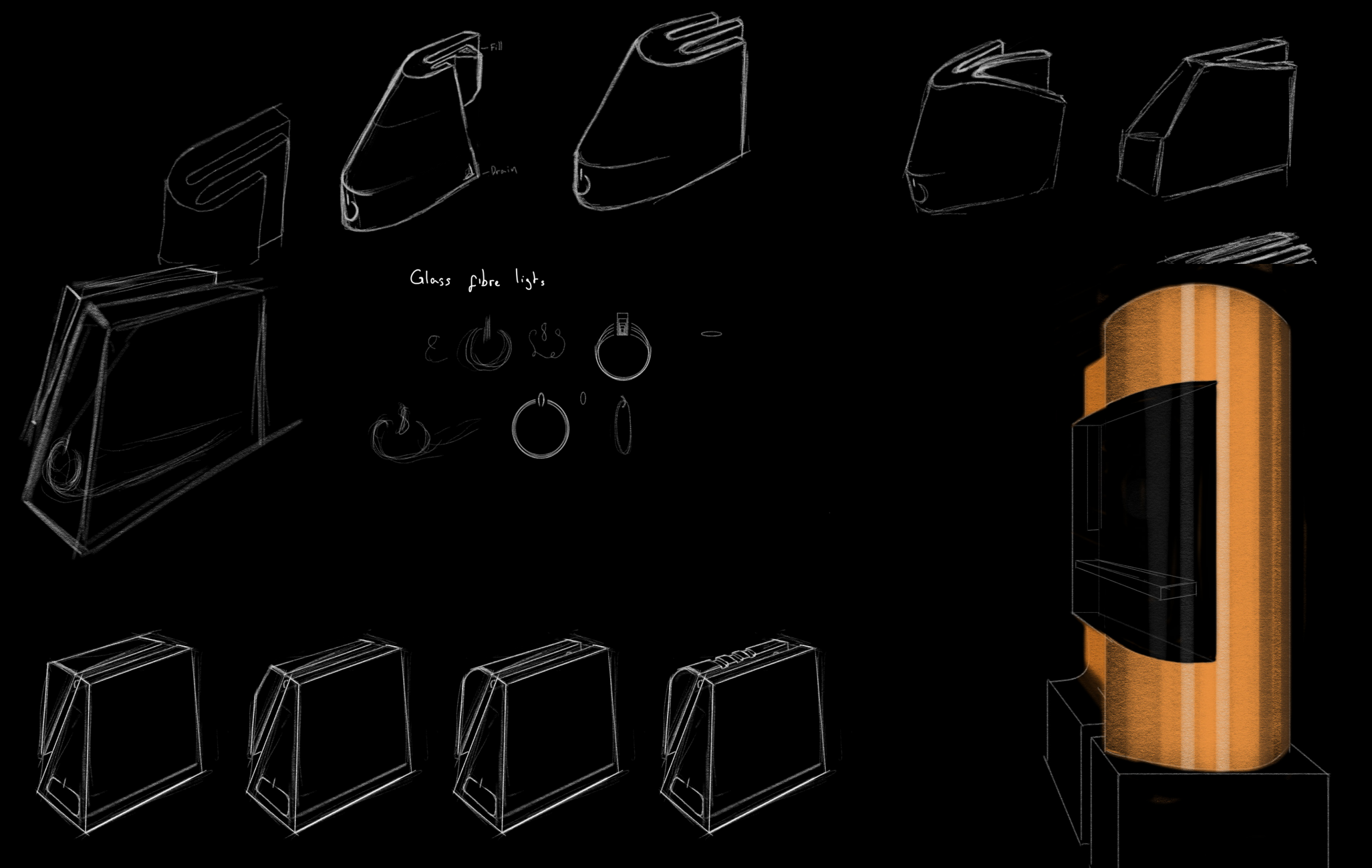
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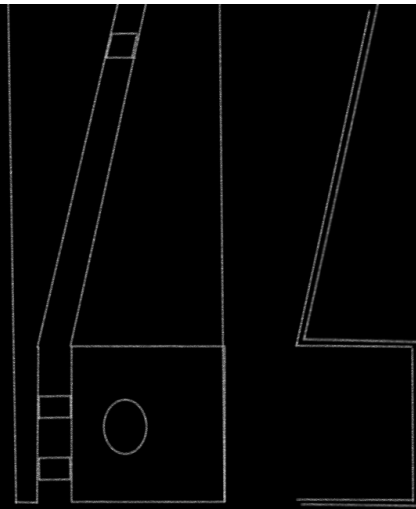
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Sketchbook

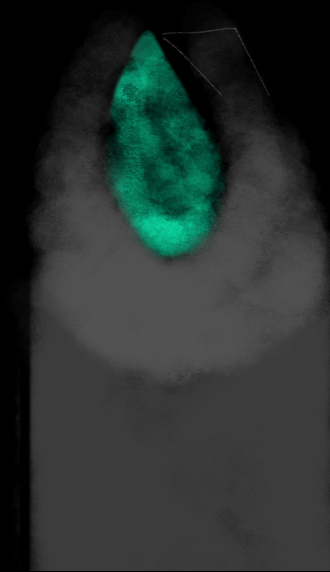
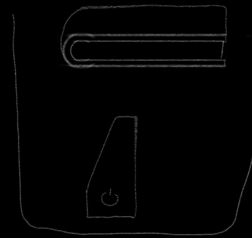








Build tray



For prototype of angled glass
 Vacuum form layers of plastic
 Linsp - GEEK Bar - transparent outside
 Less transparent inside

